Stochastic random network dynamics describes endogenous fluctuations and Event-related Synchronisation and Desynchronisation

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Experimental brain activity is known to show oscillations in specific frequency bands, which reflects neural information processing. Changes of power in frequency bands indicate changes in information processing. For instance, it has been observed that strong activity about 10Hz and 2Hz emerge in electroencephalographic activity (EEG) when a subject loses consciousness in general anaesthesia. We show numerical simulations of stochastic neural models, which exhibit such a change by changing the variance of external additive Gaussian uncorrelated noise [1]. An analytical description explains the Additive Noise-Induced System Evolution (ANISE), which is the underlying mechanism by random endogenous fluctuations.

In a next part, this noise-supported mechanism is detailed mathematically by applying random matrix theory and mean-field theory [2,3]. It is shown in unbalanced Erdös-Renyie networks including excitatory and inhibitory connections that a modification of the extrinsic noise level on the microscopic neural level tunes the frequency of neural masses on the mesoscopic level. The work demonstrates the relation to coherence resonance.

The mesoscopic mean-field equation describes experimental observations, such as Event-Related Synchronization and De-Synchronization (ERS/ERD) observed in EEG. An additional application of ANISE explains frequency switches between human occipital gamma-and alpha-oscillations when opening/closing eyes [3]. As a last application, ANISE explains the effect of transcranial Direct Current Stimulation in a ketamine animal model for psychosis [4].

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